SURA Coastal Ocean Observing and Prediction Program (SCOOP)

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Grant Number: N00014-04-1-0721
http://www1.sura.org/3000/3300_Coastal.html

LONG-TERM GOALS

The Southeastern University Research Association (SURA) Coastal Ocean Observing and Prediction (SCOOP) program includes university, government, and private sector partners working together to implement information technology (IT) solutions. The SCOOP program vision is a modular and distributed system for predicting and visualizing the coastal response to extreme atmospheric events, including the damaging and catastrophic effects of storm surge, inundation, and wind waves. SCOOP program partners are creating the "IT glue" for this interoperable system of systems by modularizing critical components and standardizing the interfaces between the modules. SCOOP emphasizes the transition of "pre-operational" research activities to operational status, and uses the real-time prediction system as an innovative research tool. SCOOP partners are turning environmental measurement and prediction into a community effort and a real-time collaboration between research institutions and operational agencies. Specifically, SCOOP's long term goals are to:

- enable coordinated observation and prediction of a wide range of phenomena such as coastal inundation, hurricane impacts, pathogen dispersal, and climate change;
- create a network of shared resources to broaden access to the requisite measurements, models, computational resources, and other key components of a real-time prediction system; and
- employ a community approach to facilitate the transition of new technology and new knowledge from research to the operational world of practical applications.

OBJECTIVES

Over the past year, the primary objectives for the SCOOP project were to:

- develop a "Model Grid" incorporating middleware and data management for real-time prediction, using a modular and standardized approach to enable broad access;
- begin to address data and metadata standards in order to help create the language of interoperability for the ocean observing community;

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2006		**00-00-2006 to 00-00-2006**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
SURA Coastal Ocean Observing and Prediction Program (SCOOP)	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Office of Naval Research,One Liberty Center,875 North Randolph Street, Suite 1425,Arlington,VA,22203-1995**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**10**	

- demonstrate a "Data Grid" for distributed data sharing, integration, and visualization using emerging standards such as the Web Services Initiatives from the Open Geospatial Consortium (OGC) (as demonstrated at www.OpenIOOS.org); and

- build community support through regional observing system pilot projects and education and outreach activities.

APPROACH

The SCOOP project is a multi-institution collaboration, bringing together a diverse group of investigators with expertise in oceanography and information technology. The SCOOP program is staffed by the Program Director, Philip Bogden; Program Manager, Joanne Bintz; and a SURA Coastal Fellow, L. Don Wright (VIMS). The SCOOP PIs working on the ONR portion of the SCOOP program are: Rick Luettich at the University of North Carolina (UNC); Sara Graves at the University of Alabama, Huntsville (UAH); Gabrielle Allen, Xiongping Zhang, and Gregory Stone at Louisiana State University (LSU); Matthew Howard at The Gulf of Mexico Coastal Ocean Observing System (GCOOS); Tom Shyka at The Gulf of Maine Ocean Observing System (GoMOOS); and Susan Cook at the Consortium of Oceanographic Research and Education (CORE). The research team is addressing SCOOP goals and objectives through activities in four major focus areas: 1) coastal modeling; 2) data stewardship; 3) computing infrastructure; and 4) community engagement.

Coastal Modeling: SCOOP coastal modeling efforts have focused on implementing various storm surge and wave models in a grid-computing environment. The UNC team, (Steve Thorpe, Lavanya Ramakrishnan, Howard Lander, Rick Luettich, Brian Blanton, Daniel Reed, Michael Garvin, and Chuck Kesler), has focused on making multiple meteorological products available through the SCOOP grid and using these to achieve ensemble computation of storm-surge. Water level forecasts are computed from each meteorological product and provided to the SCOOP visualization group. Visualization infrastructure is being implemented by Xiongping Zhang and Gregory Stone (LSU) who have designed and programmed a series of automatic tasks for transferring SCOOP model-forecasted outputs to Geographical Information System (GIS) formats and feed them to Warehouse Management Software (WMS) web services. Bechara Toulany and Will Perrie (Bedford Institute of Oceanography) have achieved progress in implementing a preliminary multi-member wave model ensemble on grid-enabled computers at LSU and the University of Florida (UF).

Data Stewardship: The focus of data stewardship is archiving and cataloging SCOOP data and information, using appropriate data and metadata standards to maximize the accessibility and utility of these valuable resources. Dr. Sara Graves (UAH) oversees data management activities, with Helen Conover and Marilyn Drewry leading development and population of the SCOOP Catalog and associated services, and Matt Smith coordinating a naming convention for SCOOP data files, which encode basic information about file contents.

Computing Infrastructure: The computing infrastructure includes enabling middleware for data exchange and transport, job scheduling and management, and computing and storage hardware for the SCOOP Grid. Ken Keiser and Matt Smith (UAH) coordinate data transport and translation among SCOOP computing and archive sites. The various modeling groups use this infrastructure as transport mechanisms to provide model input. At GoMOOS, Jason Thaxter oversees the development of a web service for the transport of SCOOP model predictions to the OpenIOOS site (www.OpenIOOS.org).

Tom Shyka provides project coordination for the SCOOP activities within GoMOOS. At LSU, Gabrielle Allen and Jon MacLaren are overseeing the development of a Grid-enabled data archive and user portal.

Community Engagement: The community building activities within the SCOOP program encompass: 1) education and outreach, 2) a visualization infrastructure to publish real-time data (OpenIOOS.org), and 3) regional observing system pilot projects at GoMOOS and GCOOS. The education initiative is led by Susan Cook at CORE in conjunction with Lee Larkin at VIMS, who are tasked to design and implement an ocean education web portal for the Centers for Ocean Sciences Education Excellence (COSEE) network and the ocean education community. Outreach at SCOOP is accomplished through participation in oceanographic and data management meetings and workshops. In particular, Joanne Bintz and Philip Bogden of the SCOOP staff with the aid of a Steering Committee to provide perspective and expertise are organizing the OOSTech '05 Workshop to engage the marine data management community in IT issues for the Integrated Ocean Observing System (IOOS). Eric Bridger (GoMOOS) is the lead developer for a real-time hurricane product available on the OpenIOOS.org website. He oversees the transport of real time observations from various organizations to the site. Jim Cradock is responsible for the OpenIOOS time series plots and the OpenIOOS HTML programming as well as maintaining the SCOOP project wiki. Matthew Howard (TAMU Oceanography) is the director of the GCOOS pilot project. GCOOS is applying the recommendations of the IOOS Data Management and Communications (DMAC) plan to GCOOS and will deliver a "lessons learned" document. In addition, GCOOS will tightly couple the outputs of the associated now cast/forecast current modeling system to NOAA's oil spill trajectory model 'GNOME'.

WORK COMPLETED

Coastal Modeling. The North Carolina prototype, grid-based, ensemble system directly connects to the SCOOP transport through Grid enabled software. Input files are received via Local Data Manager (LDM). The ensemble of storm-surge computations takes place on the SCOOP grid. To exploit existing, but under-used SCOOP computational resources, a resource selection module has been developed by Steve Thorpe and Lavanya Ramakrishnan. The resource selection module selects the best set of resources for every model run based on real-time data on available resources at each site of the SCOOP Grid.

Data Stewardship. The SCOOP Catalog design is complete. Initial population with metadata descriptions of SCOOP model results and related observational data is well underway. In June, a Data Registry application was released to the SCOOP partners. This registry guides data producers through the entry of high-level information about each data collection. A prototype Catalog search interface, completed in July, allows users to browse through the collections, and will include pointers to access data at the archives as that information becomes available. SCOOP Catalog Services support automated access to the Catalog for data archives and other applications (Fig. 1). Insert and delete services are necessarily restricted to the archives, but search services will be open to the SCOOP community.

Computing Infrastructure. The transport network is installed and functioning at seven of the nine SCOOP sites. Model forcing data and model output data, as well as data from several external data sources, are exchanged for research and archival. A file naming standard, providing significant file-level metadata, has been designed and implemented by all the participating SCOOP data

producers. A grid infrastructure based on Globus middleware is installed and functioning at five of the SCOOP sites (UF, LSU, MCNC, UAH, and UNC). The grid infrastructure components that were tested and used in the reporting period include Globus gatekeeper for job submission, GridFTP for file transfer, and Meta Directory Service (MDS) for discovering resources.

Modules have been integrated with the transport system to begin providing data translation services for the various model data sets being moved around the network. Translation services for the current version of the system have included sub-setting of model inputs for regional interest and point extraction from model data for verification comparisons with observational data sets. The SCOOP ensemble prediction system operates using translation modules that are automatically executed as data arrives at distributed transport nodes (Fig. 2), with the results either being re-inserted into the transport network or communicated to data repositories through web service interfaces.

A Grid-enabled archive has been designed and deployed at LSU. The archive ingests files arriving over different protocols (including LDM and GridFTP), and a client tool has been developed using the Grid Application Toolkit which can currently retrieve files either via GridFTP or HTTP. Queries to the archive can be made based on metadata. The archive uses MDS for logical to physical file mapping, and ingested files are verified against the file naming convention. The archive can trigger events on the arrival of specified files; this is currently used for notification of hurricane events and automatic visualization of ADCIRC data. Fault tolerance was a primary focus of the archive design. LSU has also developed a Grid portal (Figure 3) based on the GridSphere framework. Capabilities include: ensemble modeling, querying and downloading files from the archive, file movement, and monitoring of the SCOOP Grid.

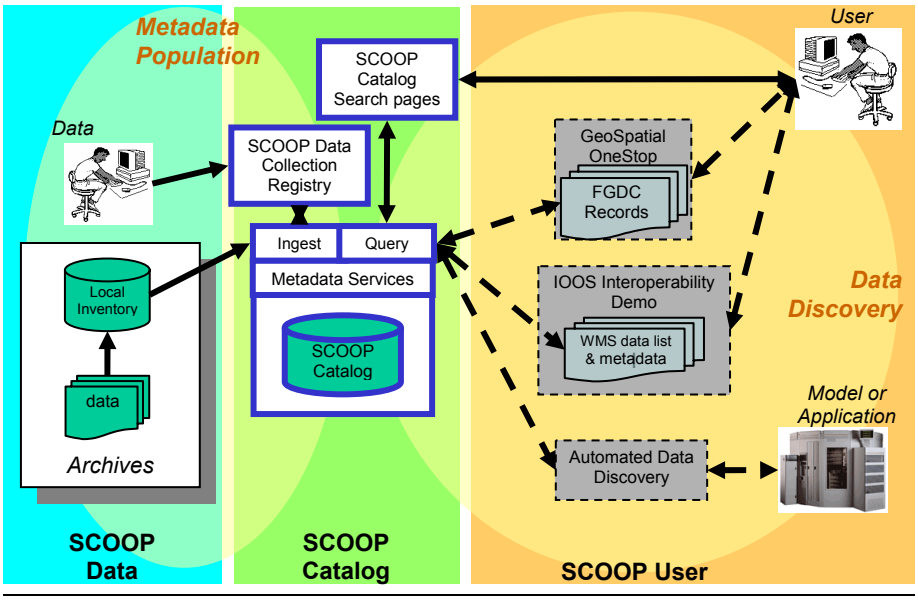

Figure 1: Current SCOOP Information Architecture
[SCOOP observations and model results are archived in local/regional data repositories. Through a web-based user interface, an individual can initiate a search of the current SCOOP catalogue for data located in any of the distributed repositories, to use in his/her own research, modeling, or other applications.]

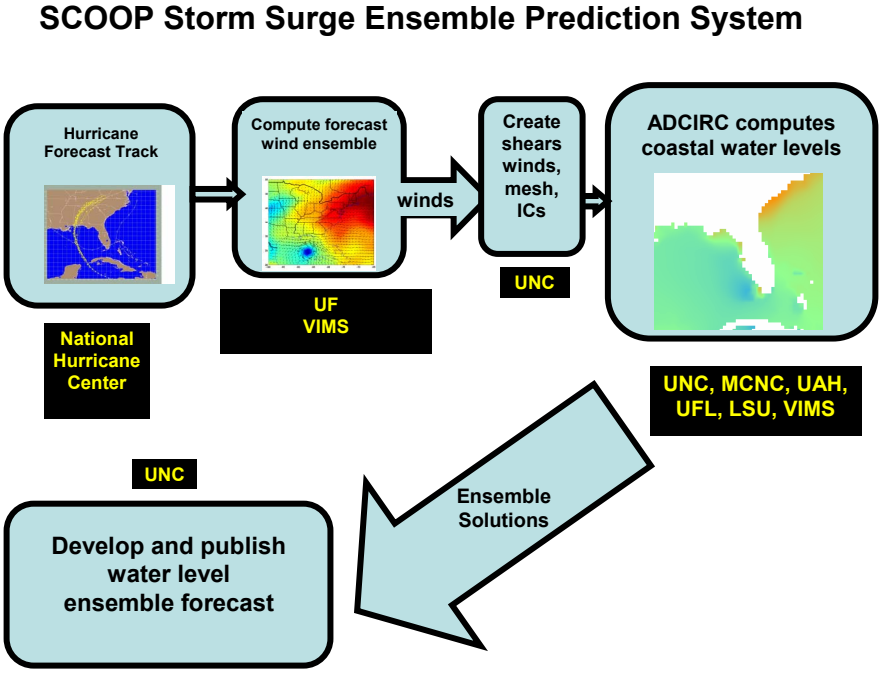

Figure 2: The SCOOP Storm Surge Ensemble Prediction System [When the NHC issues a warning, UF and VIMS pull down the advisories and system-track files and use them to compute the synthetic wind fields. Individual ensembles are created for every active storm. The ADCIRC model produces water levels for each ensemble with jobs migrating to available resources on the SCOOP grid. The ensemble solutions are exported and published.]

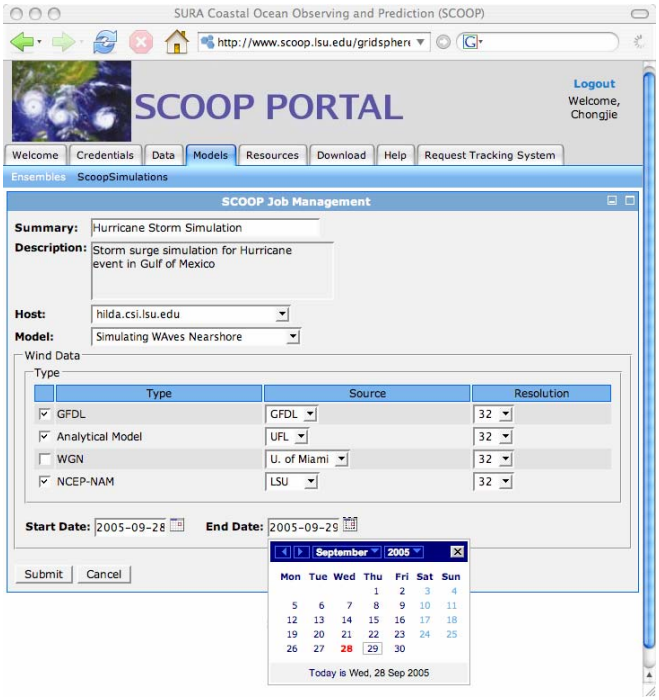

Figure 3: One interface of the LSU Portal for ensemble modeling on the SCOOP Grid using Globus and Condor.

Community Engagement. VIMS staff have created the metadata structure for COSEE and established protocols for coordinated information management. In addition, VIMS has been working with a web-design firm to finalize decisions about network-wide logo and branding issues. Internal testing is in progress with files converted from the VIMS Access database format to Extensible Markup Language (XML). The OOSTech 05 meeting will be held in Baltimore on Oct. 24-26, 2005. The agenda and logistics are available at: http://twiki.sura.org/twiki/bin/view/Main/OOSTech2005. Forecasted waves, currents, and water levels provided by SCOOP numerical modeling groups have been published in near-real-time through the OGC WMS for visualization purposes. GoMOOS launched a real-time hurricane mapping product on the OpenIOOS.org site for the 2005 hurricane season. A unique feature of the OpenIOOS hurricane product is an OGC compliant interface to view data products - including the latest observations from stations/buoys along the Southeast U.S. coast and model generated predictions for water level and wave height (Fig. 4). A retrospective for the 2005 hurricane season, constructed by GoMOOS is in the last stages of completion and will soon be available on OpenIOOS.org.

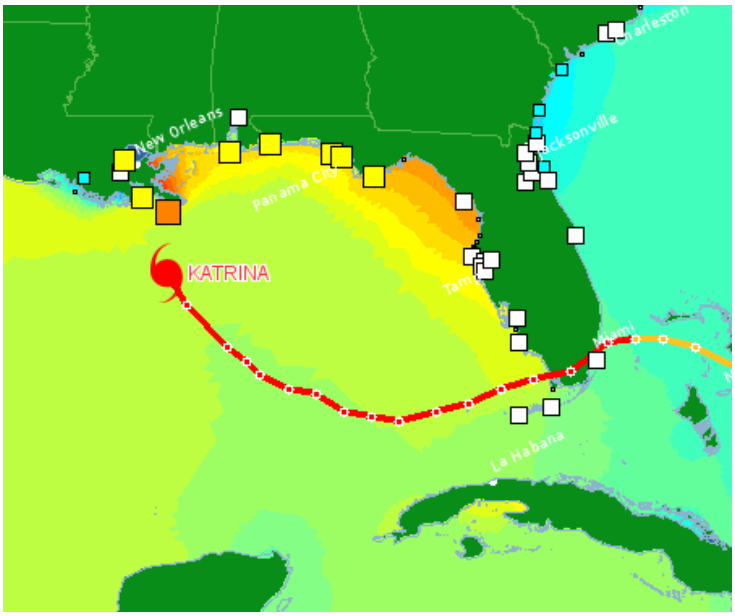

Figure 4a: OpenIOOS Map Visualizing Hurricane Katrina's path with Modeled & Observed Water Level along the Gulf Coast.

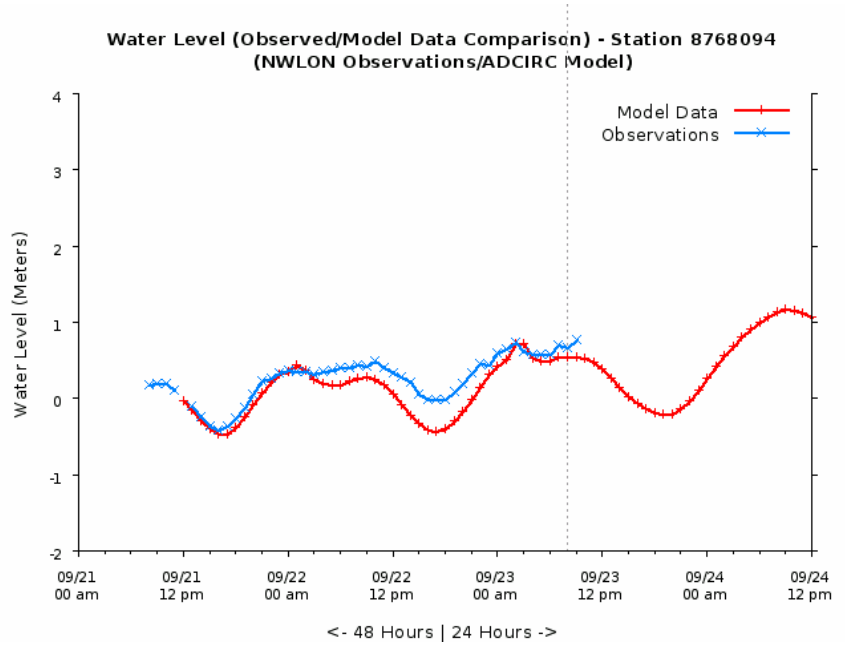

Figure 4b: OpenIOOS Plot Showing Observed Water Level at a NWLON Station & Predicted Water Level from the UNC ADCIRC Model.

RESULTS

Coastal Modeling. SCOOP partners have developed the capability to make an ensemble of storm surge model forecasts - an improvement over the traditional single model run approach. In much the way that an ensemble of meteorological models is used to achieve a better hurricane forecast, an ensemble of coastal models will allow improved forecasts of storm surge and associated flooding. Ensemble wave model forecasting is also being developed.

Data Stewardship. Taken together, the SCOOP Catalog and archives provide data discovery and access capabilities for the SCOOP community. Implementation of activities to enhance the current system will strengthen metadata and software links between catalog and archives for an improved user experience.

Computing Infrastructure. The Internet Data Distribution (IDD)/LDM transport model has proven useful, timely, and appropriate for the needs of the SCOOP transport system. However, there are persistent dependability problems with current transport node configurations that are being investigated. Resolution of these problems will be addressed with Unidata development and support staff. The integration of translation modules with the transport of data between models is proving to be an effective way of providing the output of one model as the input to another, and in the form required by the destination application. Additional translation modules will be deployed through the remainder of the project. The grid infrastructure is used to find resources using the resource selection module. Storm surge model runs trigger when data arrives through the LDM.

Community Engagement. The COSEE portal is not ready for pilot testing by external users but metadata conversion, portal design, and community education about the portal and involvement in

portal design are proceeding. SCOOP visualization tools utilizing WMS enable users to visualize a variety of model outputs in an interactive way through a web browser or other OGC compliant application (http://mitch.csi.lsu.edu/scoop/). Users can examine the detailed information from eight selectable model outputs at any spatial and temporal domain (Fig. 5). The OpenIOOS Interoperability Test bed (www.openioos.org) also uses the SCOOP model WMS. Progress in the GCOOS pilot includes the conversion of input and output elements of the data and modeling systems to OPeNDAP compatible forms, for use by NOAA/HAZMAT. These products are currently being used to track oil spills after the recent hurricanes.

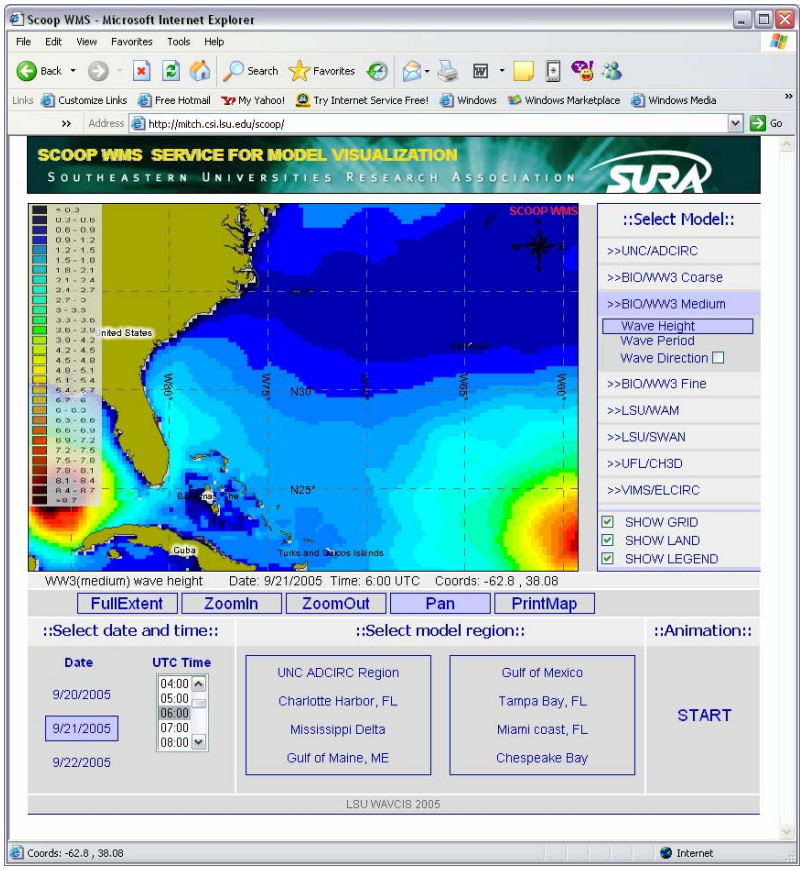

Figure 5: SCOOP WMS example.
[The map published by SCOOP WMS displays significant wave height for the Gulf of Mexico and Northwest Atlantic Ocean simulated by GoMOOS using the WW3 model.]

IMPACT/APPLICATIONS

Coastal Modeling. The evolution of the existing SCOOP modeling system will directly address the scientific concerns of storm water inundation, coupled wave-storm surge interactions, etc., by providing the computing infrastructure to simplify coordinated research in these areas. Furthermore, the same framework will provide operational products that can be used in the planning contexts.

Data Stewardship. The SCOOP Catalog and archives represent a significant community resource, especially for retrospective analysis for the 2005 hurricane season. Continued evolution of services for

accessing data and information, and strengthening ties with MMI and related ocean data systems will serve to increase the value and utility of this resource.

Computing Infrastructure. The computing infrastructure that has been established by the SCOOP project has the potentential to serve as the basis for a national level infrastructure that can be leveraged for ocean modeling, resulting in better research and forecasting capabilities. SCOOP also serves as a driving application for leveraging distributed resources such as grid environments.

Community Engagement. The conversion of www.cosee.net to an XML-based portal integrated with other ocean education DLESE resources will provide key audiences with an unprecedented, comprehensive, and powerful system for organizing and delivering ocean education information and resources nationally. SCOOP WMS, used for visualization serves the public need and can be easily accessed by users worldwide. Data can be acquired and imbedded in users' specific interfaces or applications. Forecasted data are easily shared and the model performance is assessed by model or *in-situ* observations comparisons. The GCOOS modeling system demonstrates the promise of IOOS in a real-world application with acknowledged societal benefits and clearly-identified users.

RELATED PROJECTS

OpenIOOS. The www.OpenIOOS.org website began as a proof-of-concept demonstration of data aggregation and visualization whose first implementation in the fall of 2003 occurred in less than a month and involved the Southeast Atlantic Coastal Ocean Observing System (SEACOOS) and GoMOOS. Data are currently provided by several federal and private organizations. The current vision of the OpenIOOS effort (currently known as the OpenIOOS Interoperability Test-bed) is as a growing community initiative that demonstrates interoperability among regional COTS and ONR projects, the Regional Associations (RAs) and other data sources as appropriate. SCOOP and GoMOOS have lead the development of real-time wave and storm surge observations and predictions in the south east U.S. as a demonstration of interoperability. SCOOP/GoMOOS are actively working with NOAA CSC to engage the COTS partners and RAs with the goal of developing additional demonstrations in other regions of the coast.

MMI. SCOOP is also an active participant in the Marine Metadata Interoperability (MMI) project [http://marinemetadata.org/]. SCOOP data management and standards activities are tracking MMI metadata vocabulary recommendations, and several SCOOP representatives participated in a recent MMI technical workshop on Advancing Domain Vocabularies. SCOOP hopes to participate in future MMI catalog interoperability demonstrations.

DynaCode. SCOOP participants (LSU) have recently been awarded an NSF project "A General DDDAS Framework with Coast and Environment Modeling Applications (DynaCode)" that will research and develop algorithms and technologies for realizing dynamic data driven scenarios in the field of coastal modeling.

LEAD. SCOOP participants (UNC, UAH) are also involved with Linked Environments for Atmospheric Discovery (LEAD), an NSF funded project that is building a national level cyber infrastructure for mesoscale meteorology. The issues with managing the data, enabling the models in grid environments are similar to SCOOP and activities are leveraged where possible.

SURA IT. In a separate effort, SCOOP participants are gradually adding additional Grid based resources to the available pool from which to choose computational cycles for ADCIRC model executions. These include systems from SURA member institutions, such as the University of Kentucky and the Texas Advanced Computing Center. It is likely this separate effort will in turn benefit the SCOOP project, as it may enable the automated workflow to be "hardened" to be able to utilize a wider variety of back end Grid infrastructure.

PUBLICATIONS

2005. Bogden, P., Allen, G., Stone, G., Bintz, J., Graber, H., Graves, S., Luettich, R., Reed, D. Sheng, P., Wang, H., Zhao, W. The Southeastern University Research Association Coastal Ocean Observing and Prediction Program: Integrating Marine Science and Information Technology. Proceedings of Oceans 2005 MTS/IEEE Conference. (IN PRESS).

2005. Maclaren, J., Allen, G., Dekate, C., Huang, D., Hutanu, A., and Zhang C. Shelter from the Storm: Building a Safe Archive in a Hostile World. Proceedings of the The Second International Workshop on Grid Computing and its Application to Data Analysis (GADA'05), 2005. (IN PRESS)

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